International Safeguards: Containment and Surveillance

2009 Summer Internship and Technical Safeguards Training Course

June 17, 2009

International Safeguards: the beginning….

International Safeguards: the beginning…

IAEA Statute: "*seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world.*"

IAEA Mandate: "*establish and administer safeguards designed to ensure that special fissionable and other materials, services, equipment, facilities, and information made available by the Agency or at its request or under is supervision or control are not used in such a way to further any military purpose…*"

IAEA Safeguards: the simplified process… (NPT signatory countries)

1. State authority declares intent to license/build/ operate/modify nuclear facility.
2. State completes and provides DIQ to IAEA.
3. IAEA performs DIV.
4. IAEA develops safeguards approach.
5. Inventory verification
6. Routine inspections/annual PIV

Safeguards Approach

- Hierarchical approach starting at the state level and ending with specific facilities.

"...a set of safeguards measures chosen for the implementation of safeguards in a given situation to meet the applicable safeguards objectives..."

Facility Safeguards Approach:

- Starts with generic approach for a particular facility type, then considers specific facility features and operations
- Takes into account inspection goals (based on material present), diversion scenarios, available safeguards measures, facility design, SSAC capabilities, etc.

Facility Safeguards Approach:

- Safeguards Criteria starts with facility type – LWR, OLR, RRCA, Storage Facility, etc
- For the specific facility type, the following are defined:
  - Annual PIV requirements
  - Inspection timeliness requirements
  - Containment and Surveillance (C/S) verification requirements

Containment and Surveillance (C/S) Intent

- Monitor declared activities
- Detect undeclared activity
- Detect equipment tampering
- Maintain COK (Continuity Of Knowledge) between inspections
- Reduce inspector burden

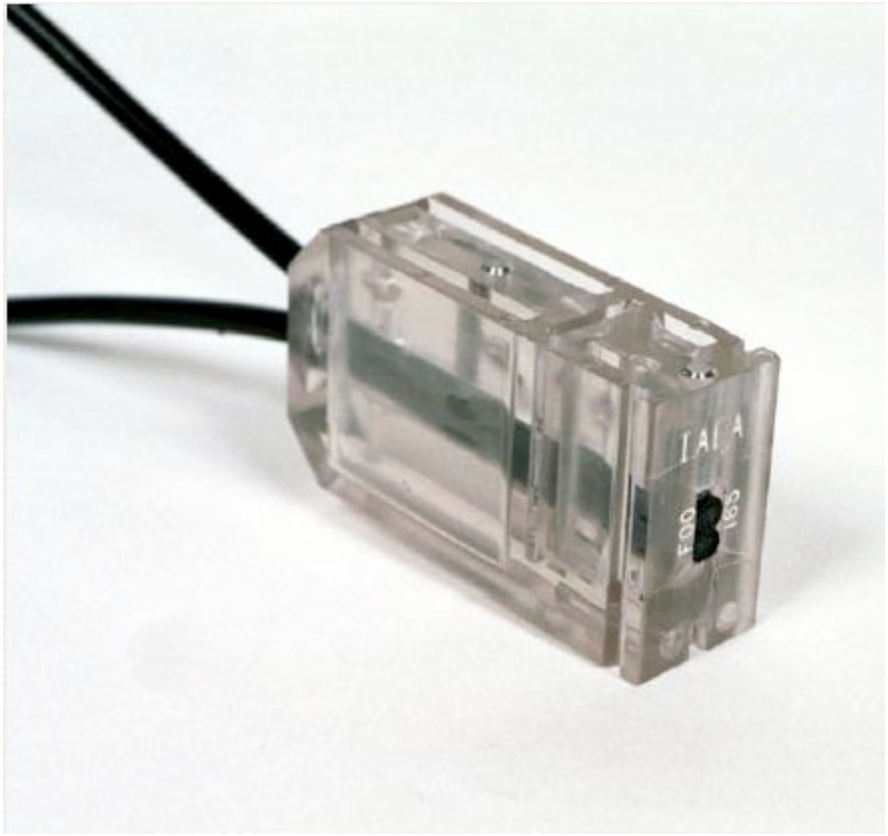
Containment and Surveillance (C/S) Types

- Sealing Devices
- Optical surveillance (digital/analog cameras)
- Radiation Monitoring
- Process Monitoring (door state, sonar, light)

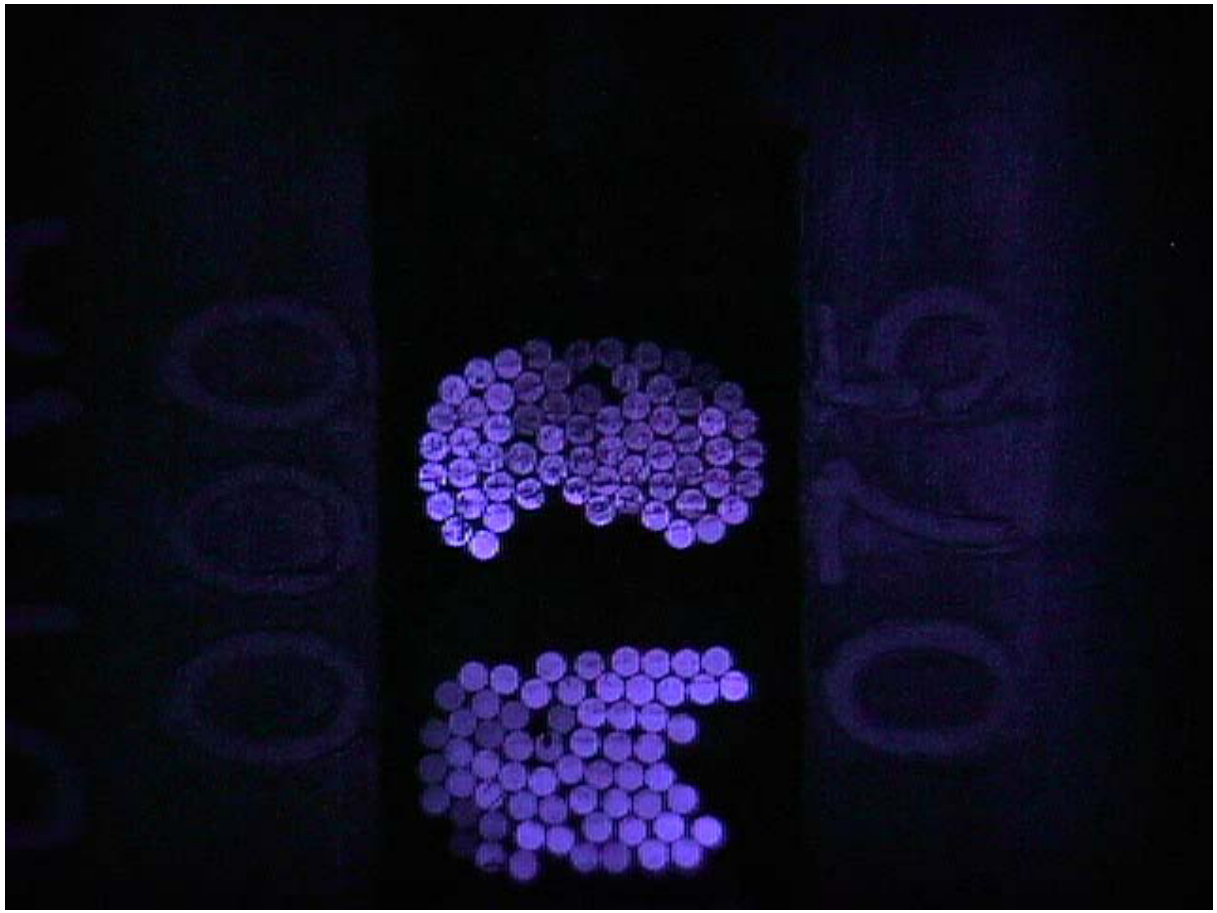
Containment and Surveillance (C/S) Single vs Dual

- If required by the safeguards approach, a dual C/S may be implemented to provide redundancy
- Dual C/S
  - Functionally independent
  - Not subject to common tampering
  - Do not share common failure mode

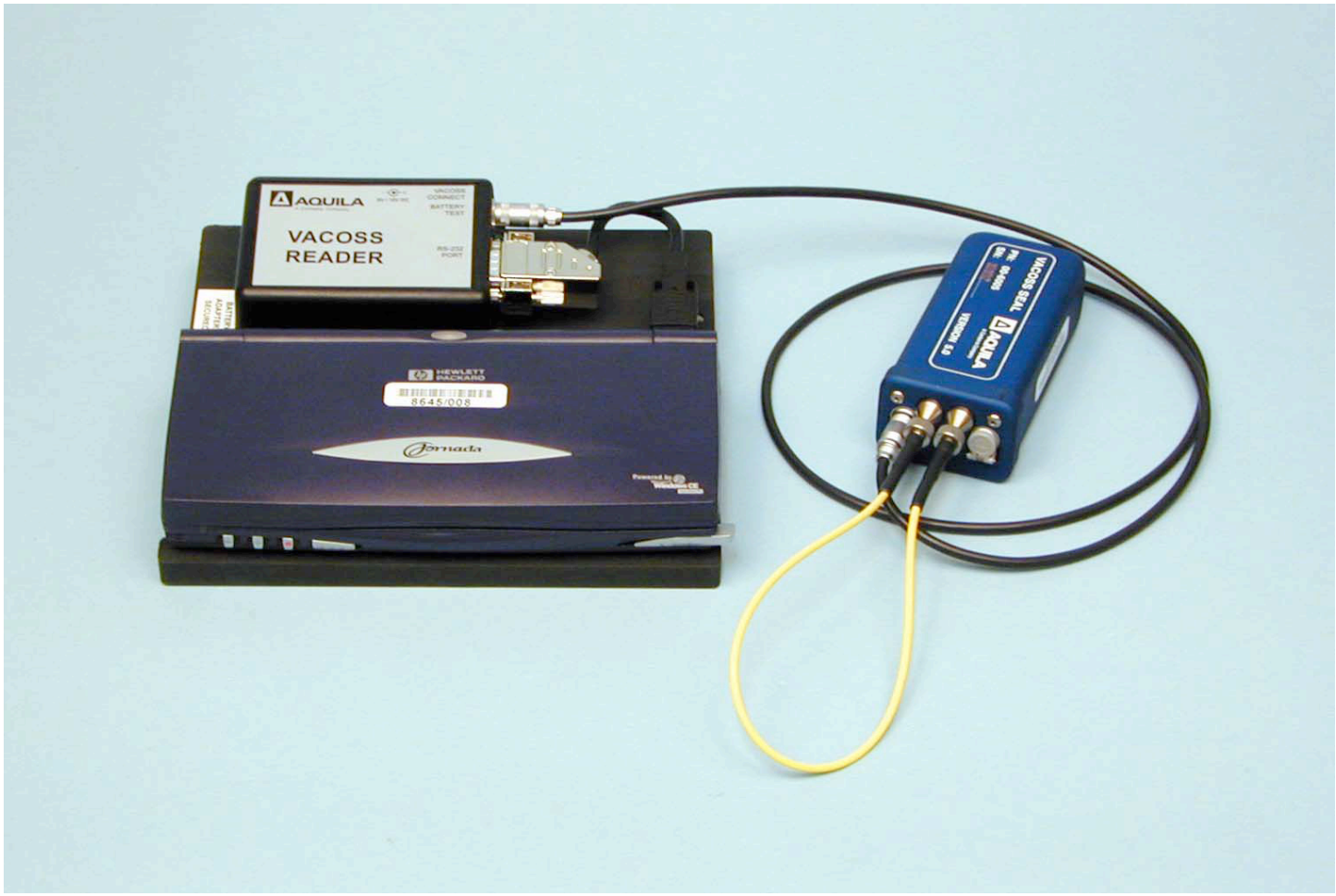
C/S Seals: COBRA



C/S Seals: fiber optic signal



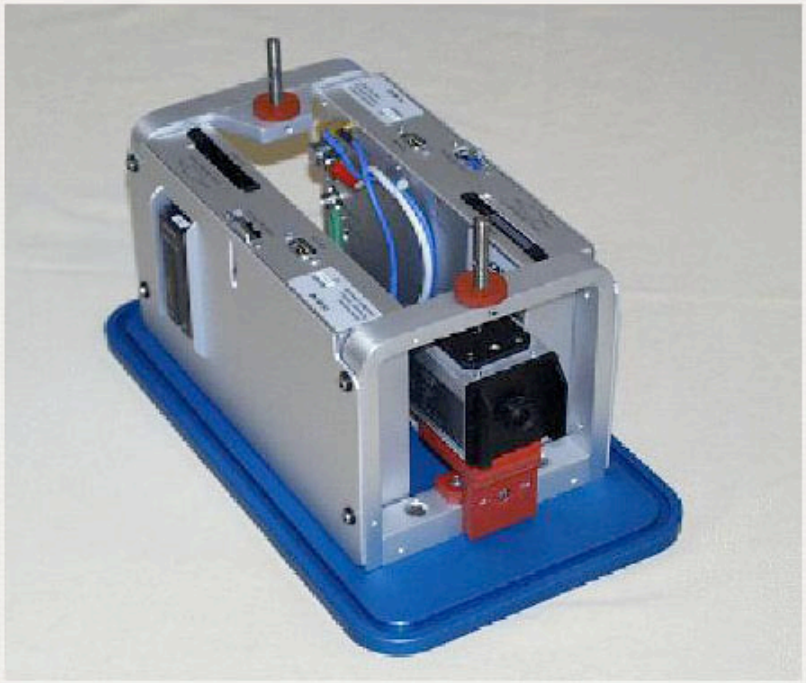
C/S Seals: VACOSS



C/S Seals: E Cup

C/S Seals: E Cup

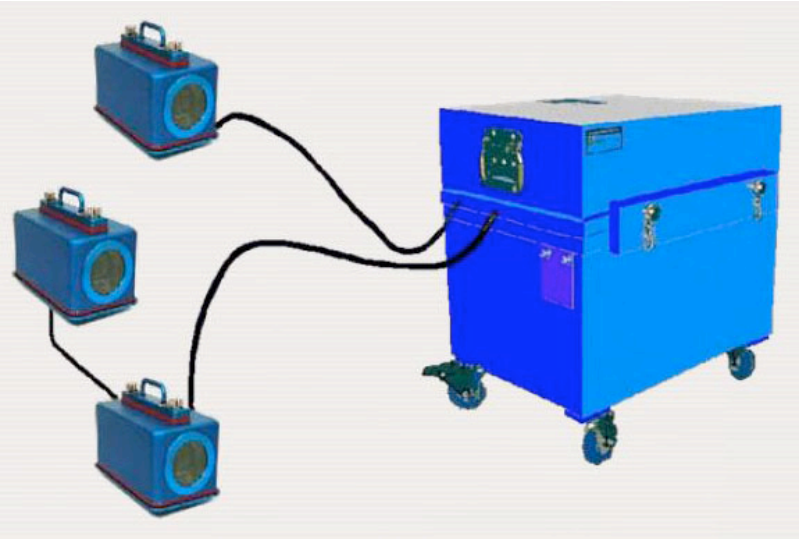
C/S Cameras: ALIS
ALl In one Surveillance



C/S Cameras: ALIP
ALl In one surveillance Portable

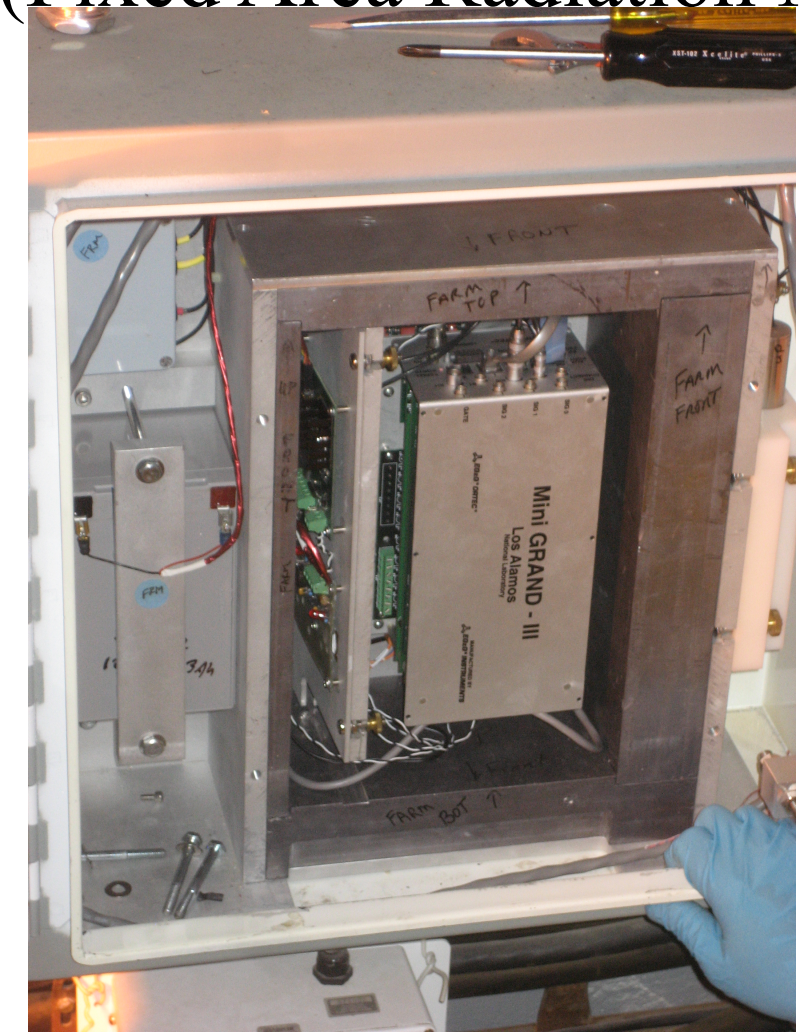
C/S Cameras: DSOS
Digital Single Camera Optical Surveillance

C/S Cameras: SDIS
Server Digital Image Surveillance



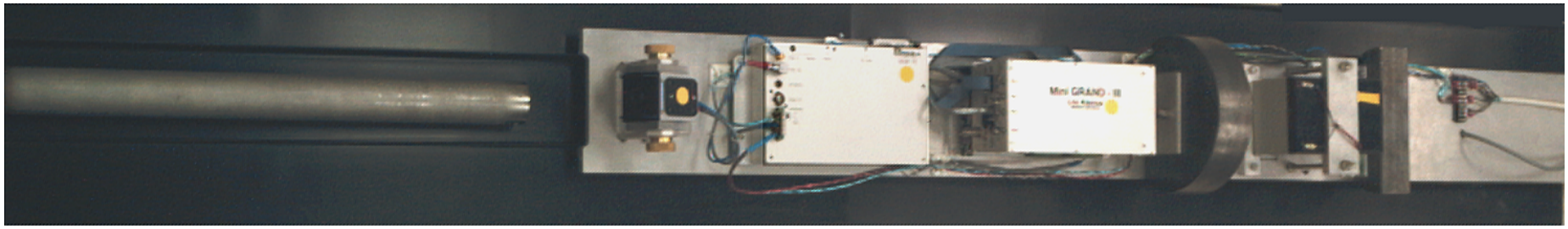
C/S Cameras: DMOS
Digital Multi-camera Optical Surveillance

C/S Radiation Monitoring: Integrated Detectors FARM (Fixed Area Radiation Monitor)



C/S Radiation Monitoring: Integrated Detectors CHRM (CHaracterization Radiation Monitor)

C/S Radiation Monitoring: Integrated Detectors
UWD (Under Water Detector)



C/S Radiation Monitoring: Integrated Detectors
UWD (Under Water Detector)

C/S Other: BMS (Balanced Magnetic Switch)

C/S case study: BN-350 Reactor

- 350 MW Fast breeder reactor
  - HEU fresh fuel
  - Pu spent fuel
- Operational 1972-1999
- Located in Aktau, Kazakhstan
- Primary purposes:
  - Electrical power
  - Desalination
  - Weapons-grade Pu for Soviet Union

BN-350 Proliferation Risks

- 1991 Kazakhstan declares independence, inheriting:
  - Nuclear-tipped ICBMs & cruise missiles
  - Nuclear testing facilities (Semipalatinsk)
  - Uranium mines, mining infrastructure
- BN-350 facility
  - HEU
  - Pu in the form of spent fuel

BN-350 Proliferation Risks

BN-350 Initial Safeguards

- 1993 BN-350 enters IAEA Safeguards & Nunn-Lugar Cooperative Threat Reduction Act:
  - Removal of HEU (2001-2005; down-blended)
  - IAEA reactor loading & discharge monitor (unattended instrumentation)
  - Rapid-response system- facility safeguards
  - IAEA Dual Containment and Surveillance (C&S)
  - IAEA scheduled inspections
  - Inventory declaration

BN-350 Safeguards

- 1997 MPC&A Implementation Agreement:
  - *"…transfer spent fuel at the BN-350 facility (to a) licensed storage facility under Category 1 International Atomic Energy Agency safeguards"*
  - *"... development of state-of-the-art monitoring of the material once in long-term storage"*

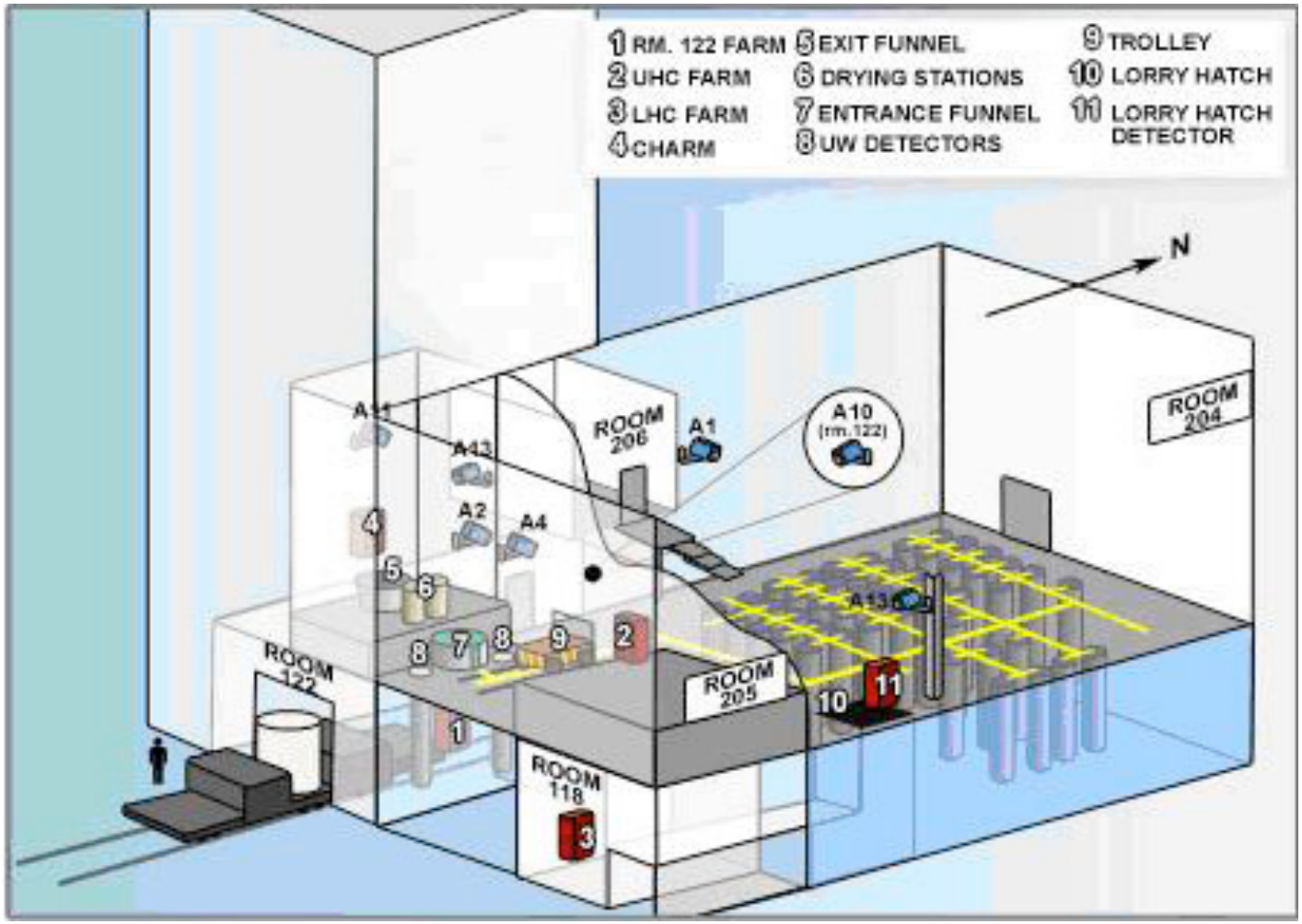
BN-350 Safeguards

- Three phase program:
  - Repackage assemblies into proliferation-resistant canisters
  - Wet storage (spent fuel pond)
  - Long term dry storage (DUC)
- Integrated unattended and attended safeguards approach
  - Characterize the material, maintain safeguards, ensure future Continuity Of Knowledge (COK)

BN-350 Safeguards Flow

- Hi risk material removal
- Facility safeguards system
- Inventory declaration
- Inventory verification
- IAEA Dual C/S Implementation
- Routine Inspections
- Annual PIV
- COK reverification (if necessary)

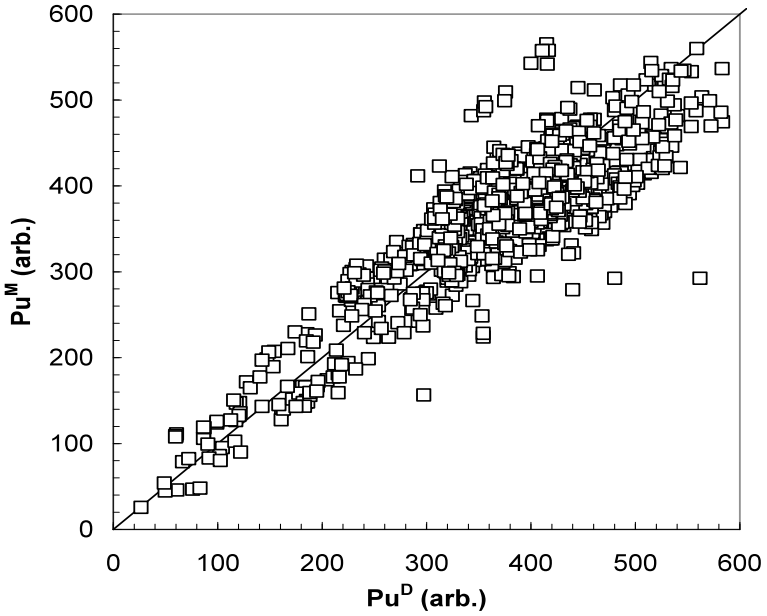
BN-350 Safeguards: C/S Layout



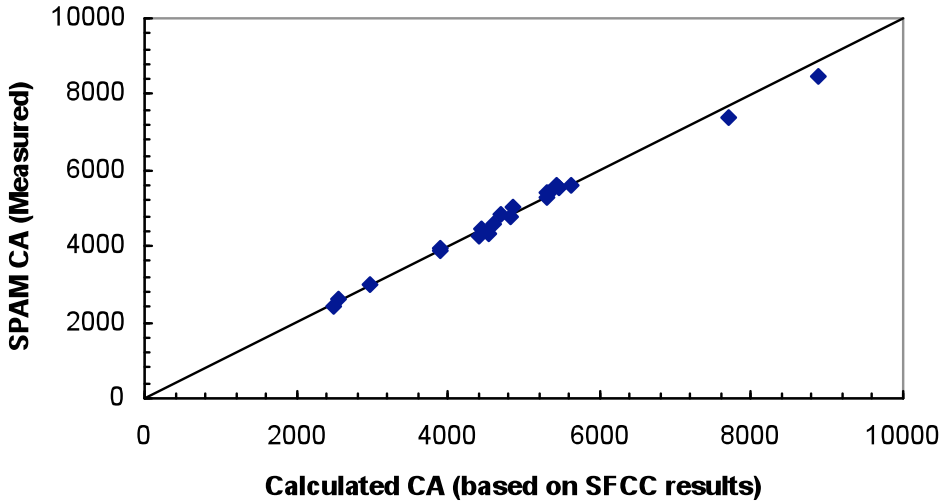
BN-350 Safeguards – Repackaging C/S

- Attended Radiation
  - SFCC (Spent Fuel Coincidence Counter)
    - Initial material characterization
    - Baseline comparison to operator declarations
  - SPAM (Spent fuel Attribute Monitor)
    - Measured confirmation of repackaging
- Unattended Radiation
  - UNARM (Unattended And Remote Monitoring)
    - Radiation-centric system of n/g detectors, and various sensors that record and archive facility operations for later review by the IAEA
- Seals
  - COBRA
  - VACOSS
  - E CUP
- Optical Surveillance
  - SDIS
  - DMOS

BN-350 Safeguards - SFCC



BN-350 Safeguards - SPAM



BN-350 Safeguards – UNARM

Hardware

- Detectors
- Family of Intelligent Instruments
- Intelligent Data Network Nodes
- Data Collection Computer
- Cameras
- Video Servers
- RAID, UPS, Failover
- Integrated Review Computer
- Remote Capabilities

BN-350 Safeguards – UNARM

Software

- Monitor in the Instruments (MiniGRAND)
- Intelligent Network Node Software (ILON)
- Data Collection Software (MIC & utilities)
- Integrated Review & Analysis Software (IRS)
- Remote Status/Data Access Capabilities

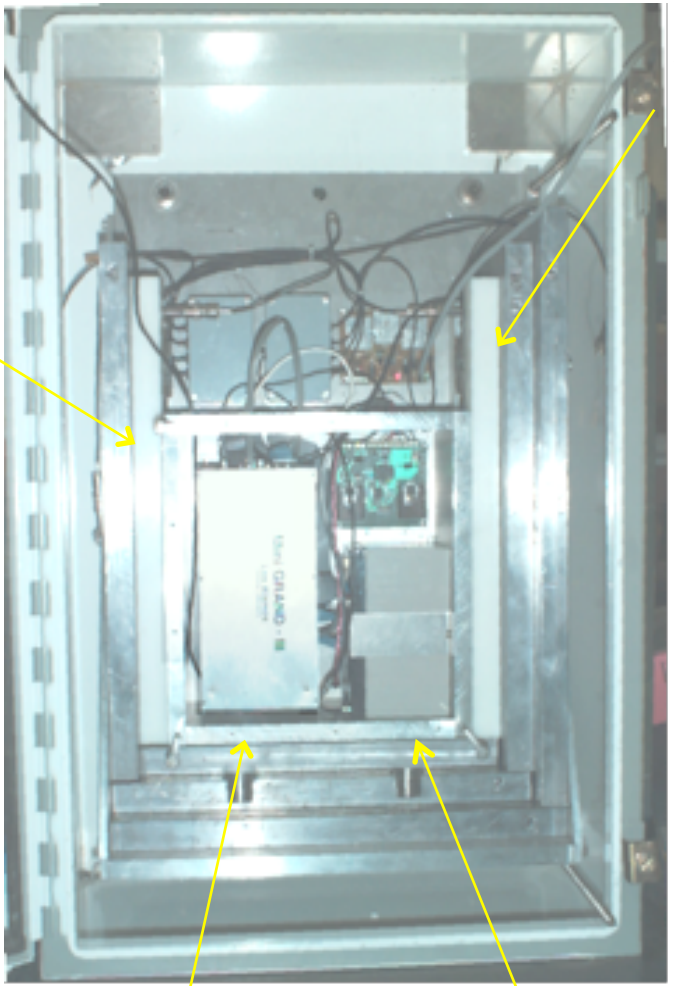
BN-350 Safeguards – Detectors

Senses nuclear and non-nuclear material in the hot cell

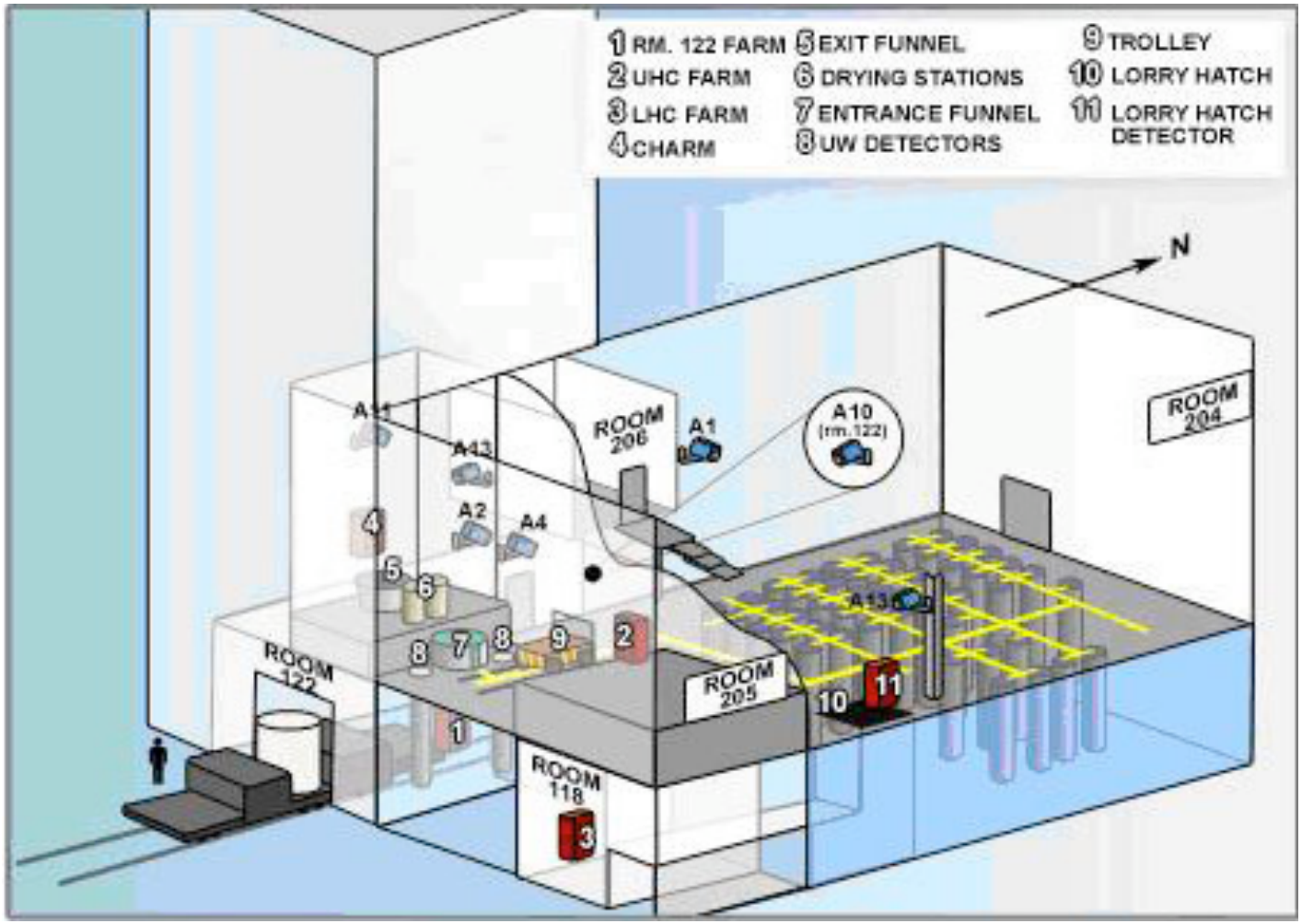
Contains 4 ^{3}He tubes and shielded and unshielded ion chambers

Integrated detector, shielding, instrument and ILON with battery

Contained in sealed box with only power and ILON cables extruding

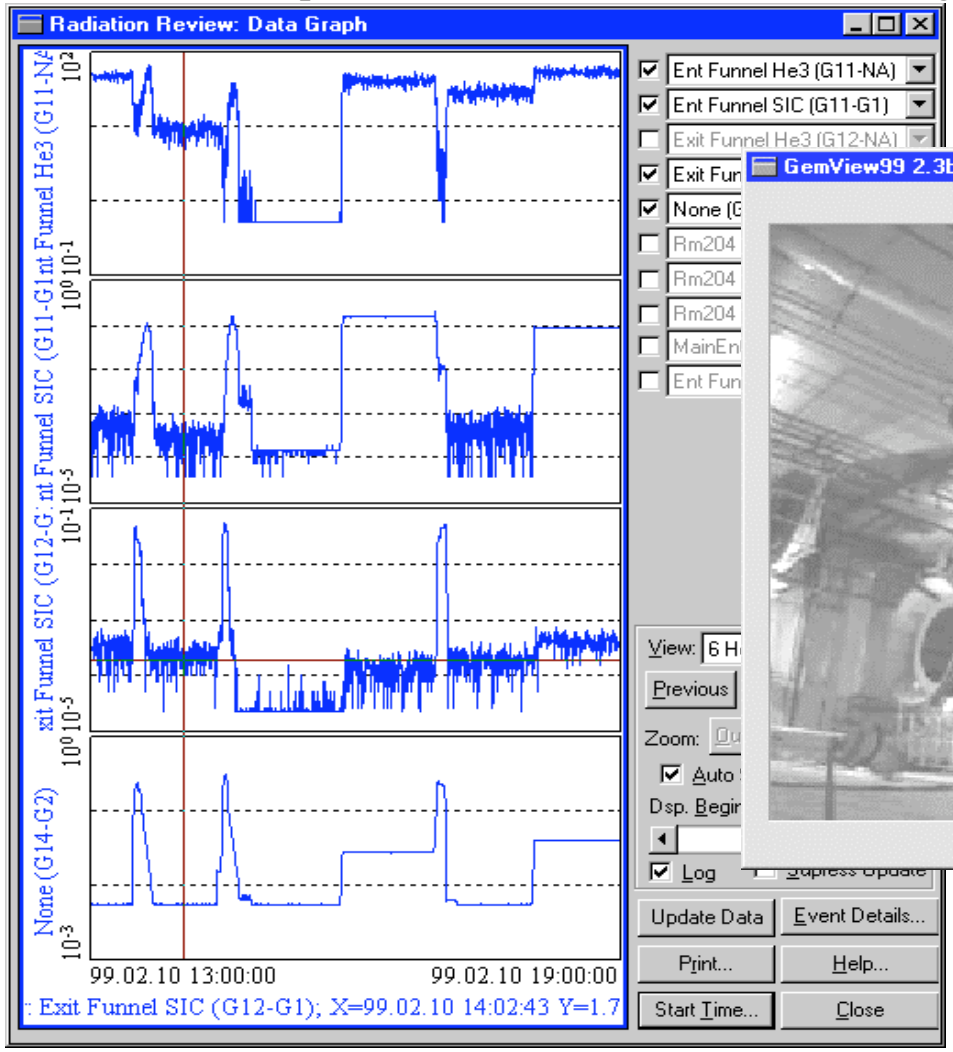


BN-350 Safeguards: C/S Layout

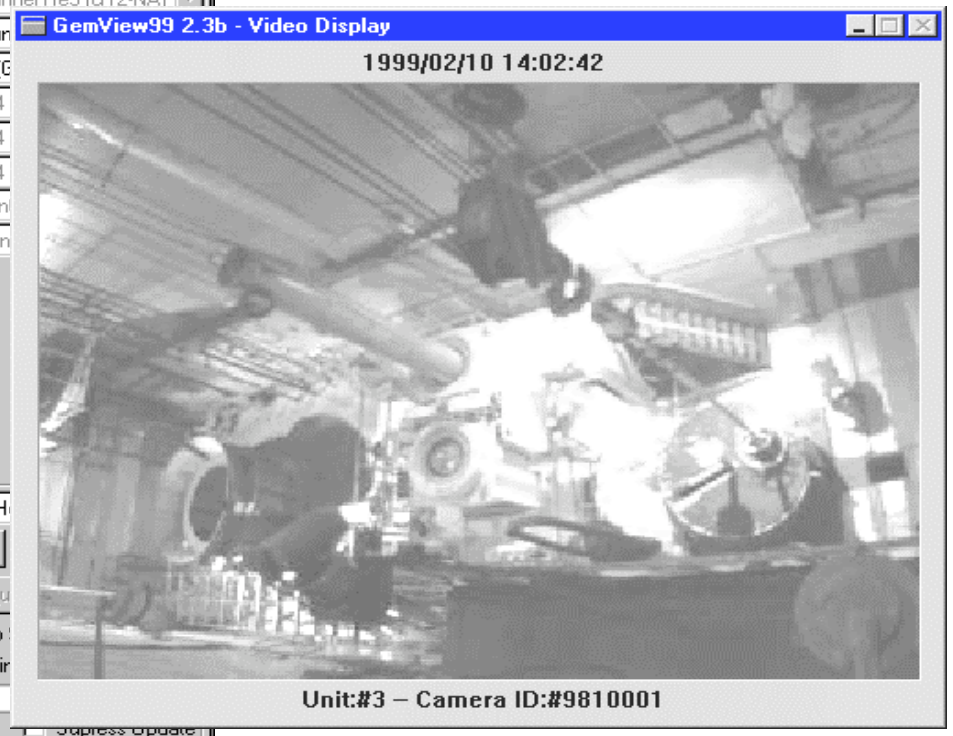


BN-350 Safeguards – Data Review

Radiation Review strip chart shows time-based radiation signatures



Data can be matched from one review to another.



Digital Video Review displays the images associated with the time indicated by the strip chart cursor.

BN-350 Safeguards – Wet Storage C/S

- Attended
  - SPAM
    - Optional measurements to maintain COK
- Unattended
  - Original UNARM with enhancements
    - IAEA continued routine inspections
    - UNARM reinforced to cover areas where activity is focused
- Seals
  - COBRA
  - VACOSS
  - E CUP
- Optical Surveillance
  - SDIS
  - DMOS

BN-350 Safeguards – Dry Storage C/S

- In progress now
- Attended
  - Dual Slab Verification Detector (DSVD)
    - "Fingerprint" measurement
- Unattended
  - Evolutionary UNARM
    - Monitoring that remains with each cask
  - IAEA continues routine inspections
    - Review of UNARM data
- Seals
  - COBRA
  - VACOSS
  - E CUP

BN-350 Safeguards

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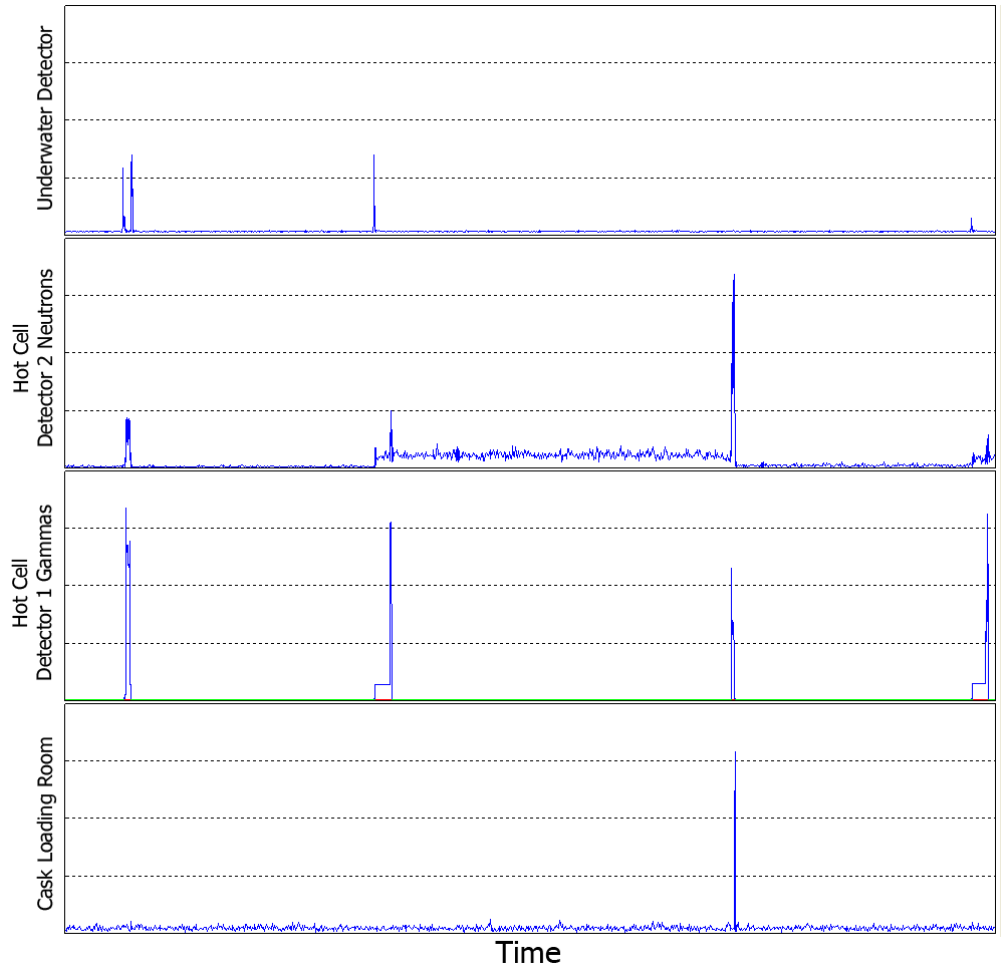
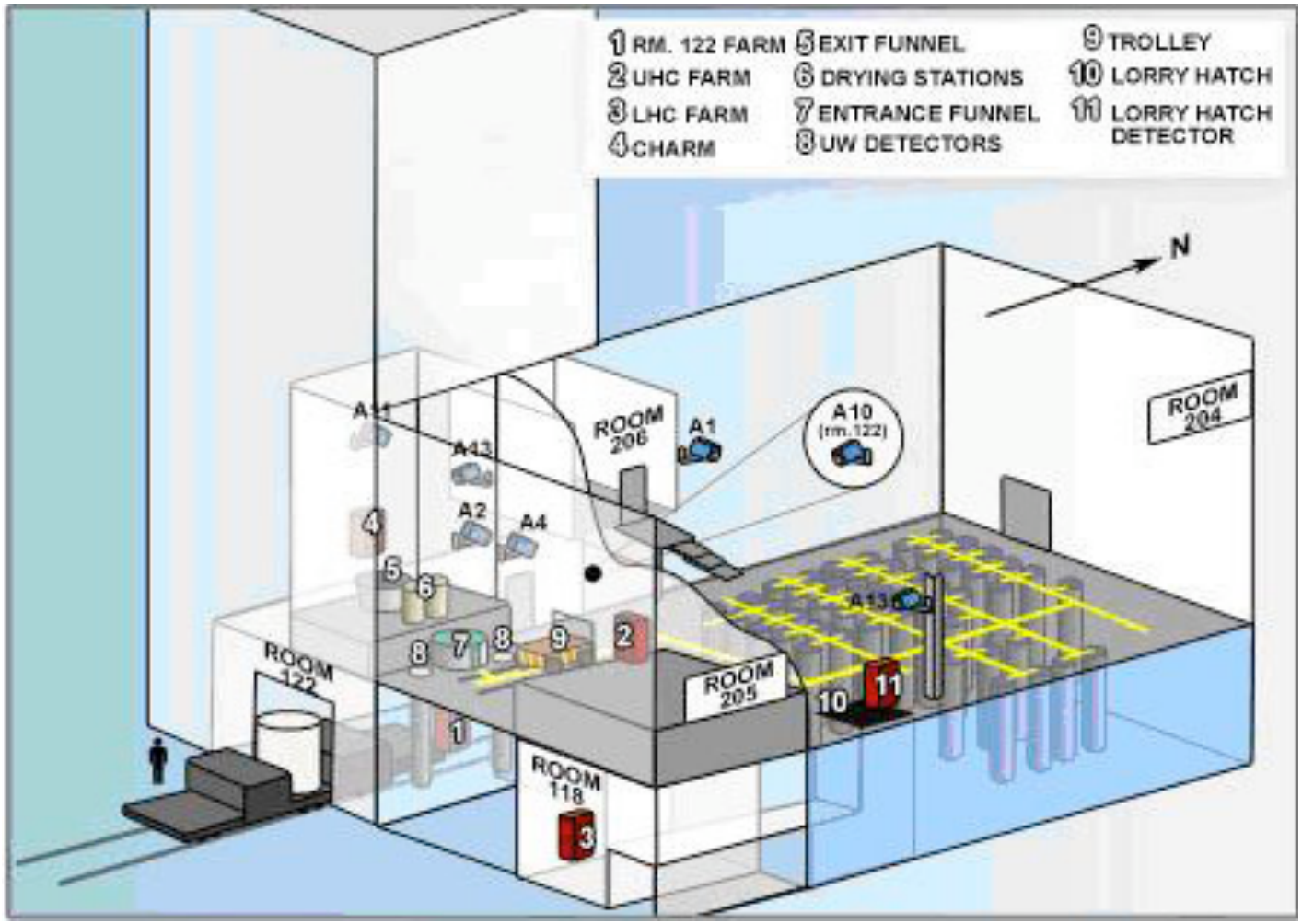
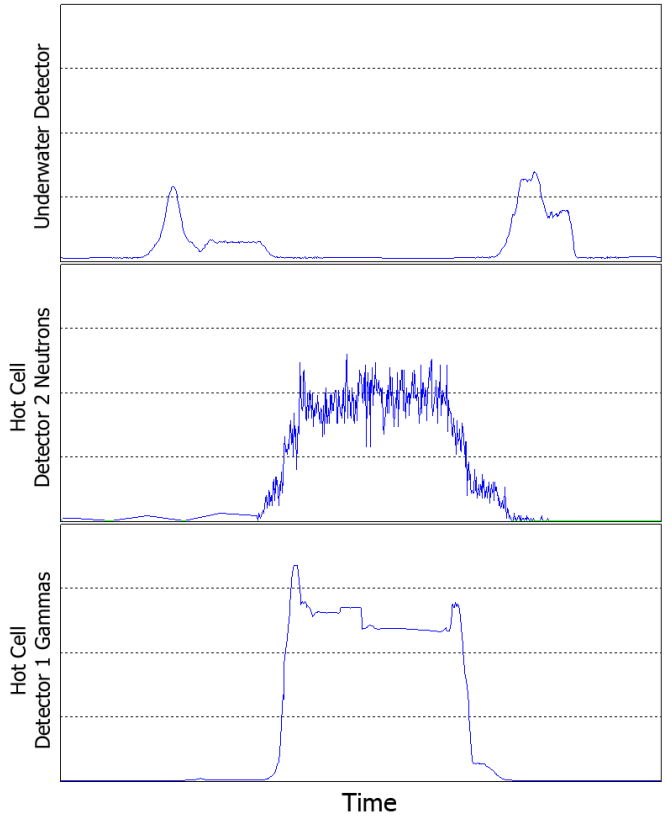


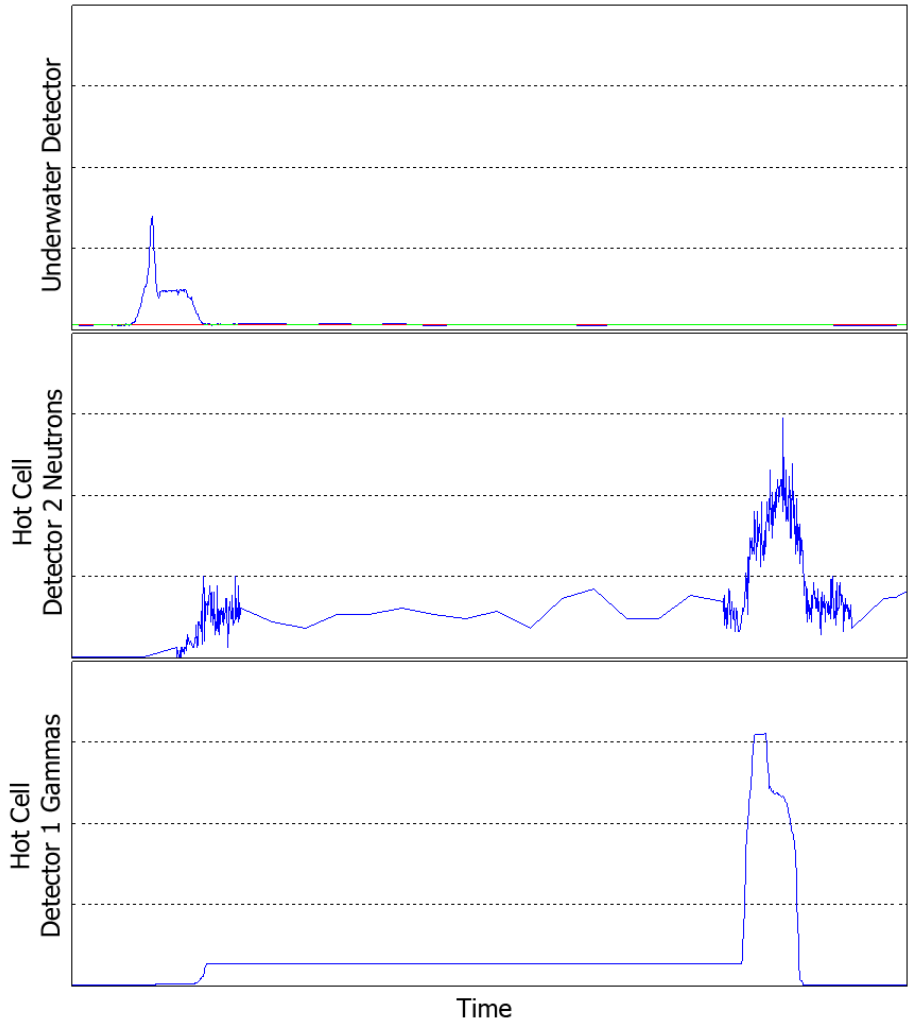
Time-synchronized data over a period of two days from four different detectors within the UNARM system

BN-350 Safeguards: C/S Layout

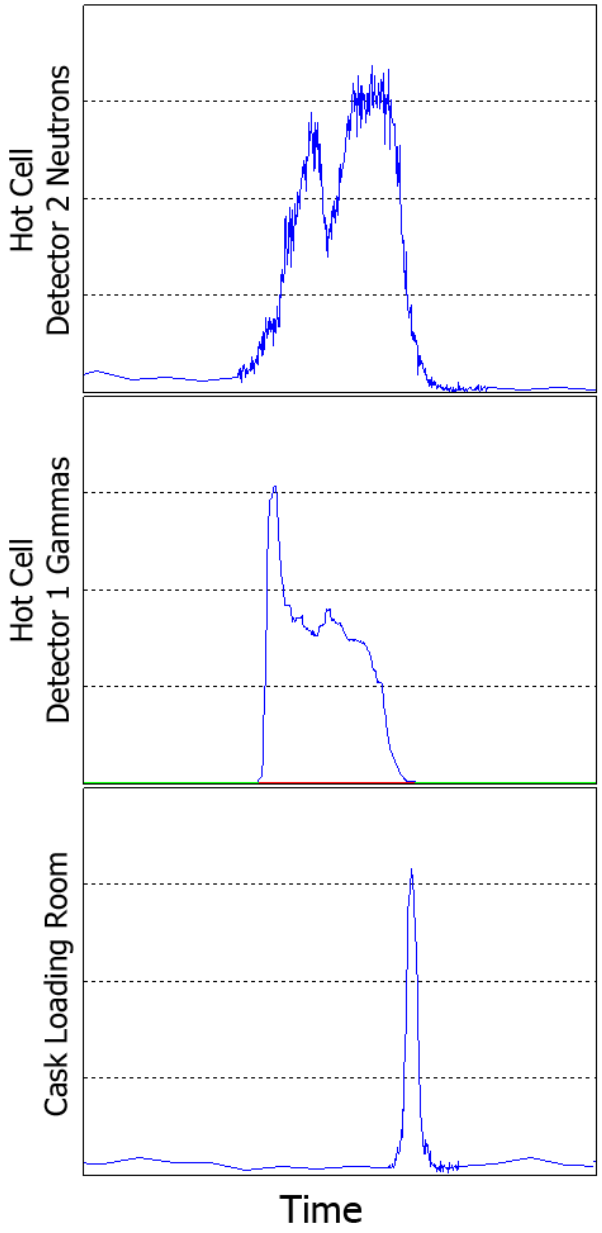




A close-up in time of the initial failed attempt to load the first canister into the cask



A close-up of the drip-dry period and loading of the first canister into the welding/drying station



The end of a successful cask loading event